THE TRANSMISSION PLANT OF THE NIAGARA, LOCKPORT AND ONTARIO POWER CO.

RALPH D. MERSHON

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POWER COMPANY

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POWER DISTRICT
OF
THE ONTARIO POWER COMPANY
OF NIAGARA FALLS.
The Niagara, Lockport & Ontario Power Co.,
Transmission Lines: Finished Proposed
The Ontario Transmission Co., Limited,
Transmission Lines: Finished Proposed
Sub Stations
Steam Railroads: Electric Railways: Finished Proposed
Scale of Miles.
LAKE ONTARIO
LAKE ERIE
PENNSYLVANIA
Hamilton
Buffalo
Rochester
Niagara Falls
Lockport
Oswego
Syracuse
Ithaca
Elmira
Binghamton
Jamestown
NIAGARA
ORLEANS
GENESEE
MONROE
WAYNE
LIVINGSTON
WYOMING
ONTARIO
YATES
SENECA
CAYUGA
ONONDAGA
OSWEGO
CORTLAND
TOMPKINS
SCHUYLER
CHEMUNG
TIOGA
ERIE
CHAUTAUQUA
CATTARAUGUS
ALLEGANY
STEUBEN

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THE TRANSMISSION PLANT OF THE NIAGARA, LOCKPORT AND ONTARIO POWER COMPANY

BY RALPH D. MERSHON

ON the seventh day of July, 1906, there was put into operation the first of the transmission lines of the Niagara, Lockport and Ontario Power Company. This event marks the inauguration of one of the first undertakings in the matter of distributing Niagara power over a large section of country, and the beginning of an enterprise which is one of the most important, and in some respects the most important, of its kind anywhere in the world.

The plans realized at present and contemplated for the immediate future, in the plant of the Niagara, Lockport and Ontario Power Company, involve a maximum transmission distance of 160 miles. This distance puts the plant amongst the longest transmissions of the world. As regards capacity, the plant of the Niagara, Lockport and Ontario Power Company is now one of the most important in existence, and, in the near future, its capacity will be far in excess of any other transmission system in the world. In addition to these points of importance, there are a number of engineering features somewhat out of the usual line of transmission practice which make the installation of interest from an engineering standpoint. Inasmuch as the description of such a plant is usually more satisfactorily accomplished through pictures than otherwise, they will be mainly resorted to herein, with the aid of such brief text only as may be necessary to cover points which cannot be well shown in illustrations.

The prospective system of the Niagara, Lockport and Ontario Power Company is a comprehensive one for the delivery of power in the United States within an economic transmission radius of Niagara Falls, and especially for its delivery in the northern and western portions of the state of New York. The company expects within the next two years to be transmitting 60,000 horse power, and its present right-of-way purchases are with reference to an ultimate transmission of 180,000 horse power. The plans of the company as at present laid out contemplate the transmission of this power by means of main lines and branch lines therefrom; the

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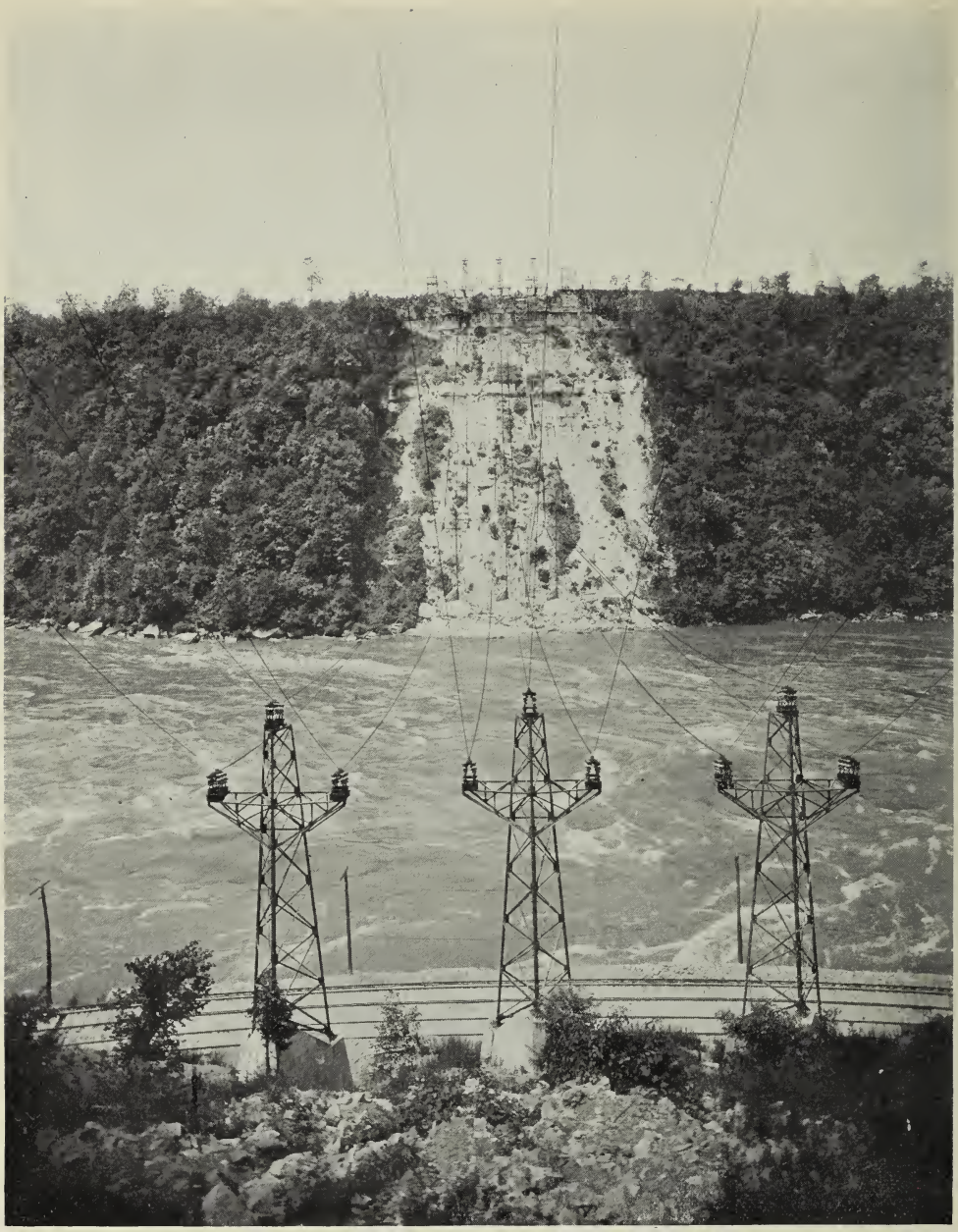


NIAGARA CROSSING, GENERAL VIEW

contracts for power being, wherever possible, made for delivery of the power at the main-line voltage of 60,000 less line drop. Where, however, the business of a given territory will justify it, the company will install step-down transformer stations for the delivery of power at a lower voltage. Each of the main transmission circuits will be capable of receiving and

NIAGARA CROSSING, WATER EDGE TOWERS AMERICAN SIDE

transmitting 30,000 horse power at 60,000 volts, and it is intended always to provide a sufficient number of spare main transmission lines to insure continuity of service on the main line. Spare lines will be provided in the case of branch lines only when the latter are of considerable importance.

The Niagara, Lockport and Ontario Power Company is a transmission company only; that is, it buys the power to be transmitted and has, there-

NIAGARA CROSSING, TOP OF WATER EDGE TOWERS

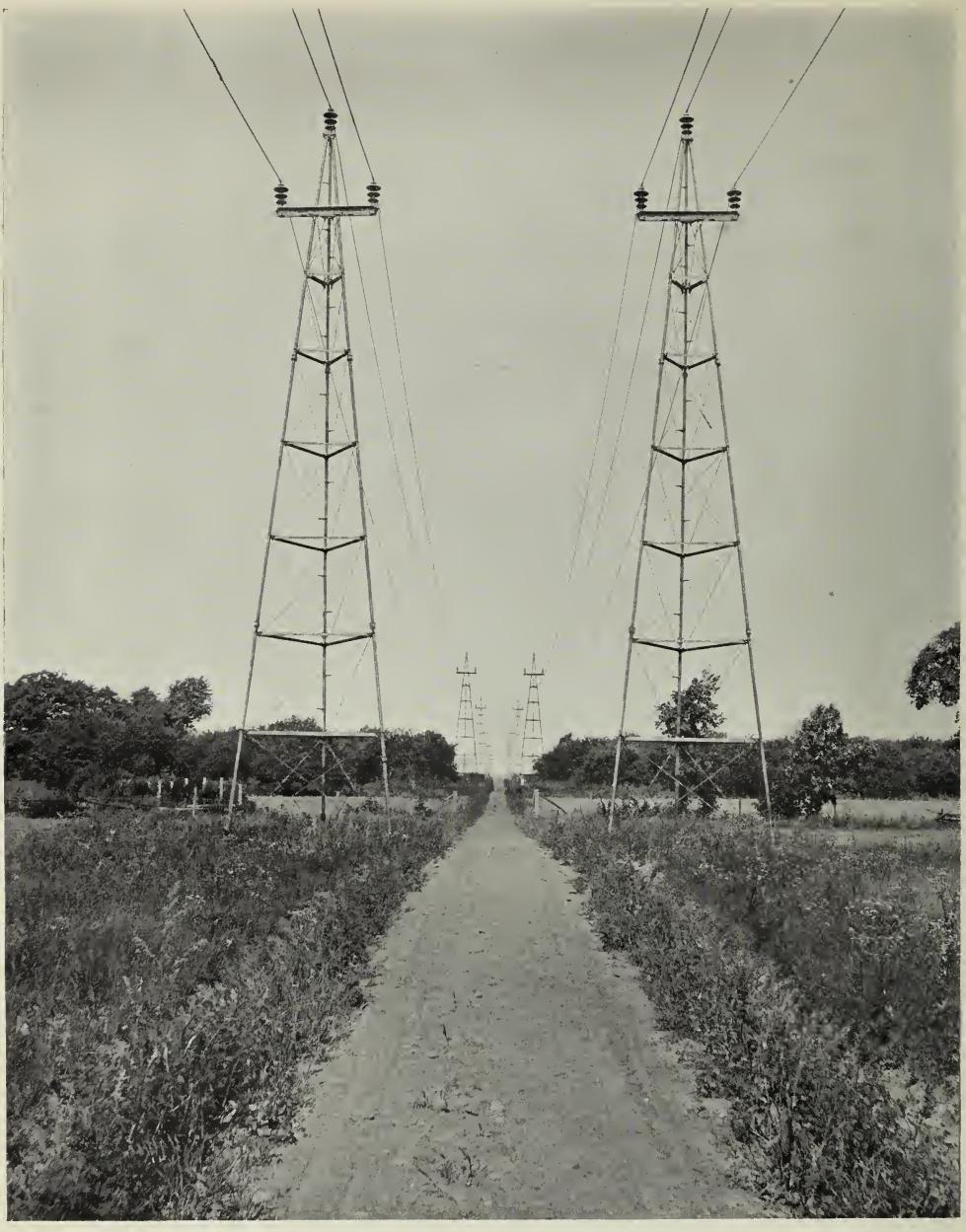
fore, no generating plant of its own. The power for the transmission is generated in the hydraulic power station of the Ontario Power Company, situated on the Canadian side of Niagara Falls. The water for this station is taken from the Niagara River, some distance above the Falls, whence it is brought to a point at the top of the cliff, a short distance below the Falls, through underground steel conduits, and from this point delivered through underground penstocks to the power station located at the bottom of the cliff, near the foot of the Falls.

The power house contains the generating units with their exciters and switchboard apparatus. The generators have a capacity of 7,500 k. w. each, and deliver three-phase, 25-cycle current at 12,000 volts. From the power station the current is taken at 12,000 volts to the transforming and switching station of the Ontario Power Company located on the bluff above the Falls. It is stepped up from 12,000 volts to 62,500 volts, and at this latter voltage delivered to the transmission lines. The transmission lines of the Ontario Power Company extend from their transforming station to a point some six miles farther down the Niagara River, at which point

the lines connect to circuits spanning the Niagara River. The Niagara, Lockport and Ontario Power Company takes delivery of the electric power at the international boundary line in the middle of the Niagara River.

At the present time, the Niagara, Lockport and Ontario Power Company have in their possession a private right-of-way 300 feet wide from the Niagara River to the town of Lockport, about 16 miles east; from Lockport east to Mortimer (six miles south of Rochester), a private right-of-way 200 feet wide, a distance of about 57 miles; from Mortimer to Fairport a 100-foot private right-of-way a distance of 10 miles; from Fairport to Syracuse a private right-of-way 75 feet wide, a distance of 71 miles. From Lockport south, in the direction of Buffalo, the company has a private right-of-way 100 feet wide. In addition to this, the company has the right to install transmission lines on the right-of-way of the West Shore Railway Company, and has acquired the necessary private right-of-way to get from their main private right-of-way to that of the railway company. The location of the various transmission lines constructed and in contemplation are shown on the accompanying map.

NIAGARA CROSSING, CANTILEVERS, AMERICAN SIDE



PIPE TOWERS

The installation which the company has now in operation is for receiving 30,000 horse power and delivering this amount, less the line loss. The main transmission consists of two lines in duplicate. From the Niagara River to Lockport, a distance of 16 miles, there are two lines on the company's private right-of-way, each capable of transmitting 30,000 horse

TRANSMISSION LINES FROM LOCKPORT TO BUFFALO

950-FOOT SPAN OVER BUFFALO CREEK

power. From Lockport to Mortimer, a distance of 57 miles, there is a line on the company's private right-of-way having a capacity of 20,000 horse power. From Mortimer east to Syracuse, a distance of 81 miles, there is a line on the company's right-of-way, having a capacity of 10,000 horse power. From Lockport to a point about 11 miles east and thence south on the company's private right-of-way to the West Shore, thence on the West Shore to Pittsford is a line having a capacity of 20,000 horse power. From Pittsford on the West Shore right-of-way east to Syracuse is a line having a capacity of 10,000 horse power. From Lockport south to a point south of Buffalo, there are two transmission lines on the private right-of-way of the company, each having a capacity of 30,000 horse power. These two lines south are tapped into the two lines coming from the Niagara River to Lockport, and constitute, therefore, at present, a branch line; but they will be eventually extended clear through to the Niagara River, and it is in anticipation of this extension that they are constructed with the full capacity of 30,000 horse power. As will be seen from the above, the distance from the Niagara River to Syracuse is 154 miles. In addition to this, the transmission from the transforming station of the Ontario Power

Company to the Niagara River has a length of about 6 miles, making, as previously mentioned, a maximum transmission of 160 miles.

It will be seen, therefore, that in delivering power in Lockport, in the neighborhood of Buffalo, Rochester, Syracuse, and at intermediate points, the company will have transmission circuits in duplicate, each capable of transmitting the full amount of power to be delivered at the several points.

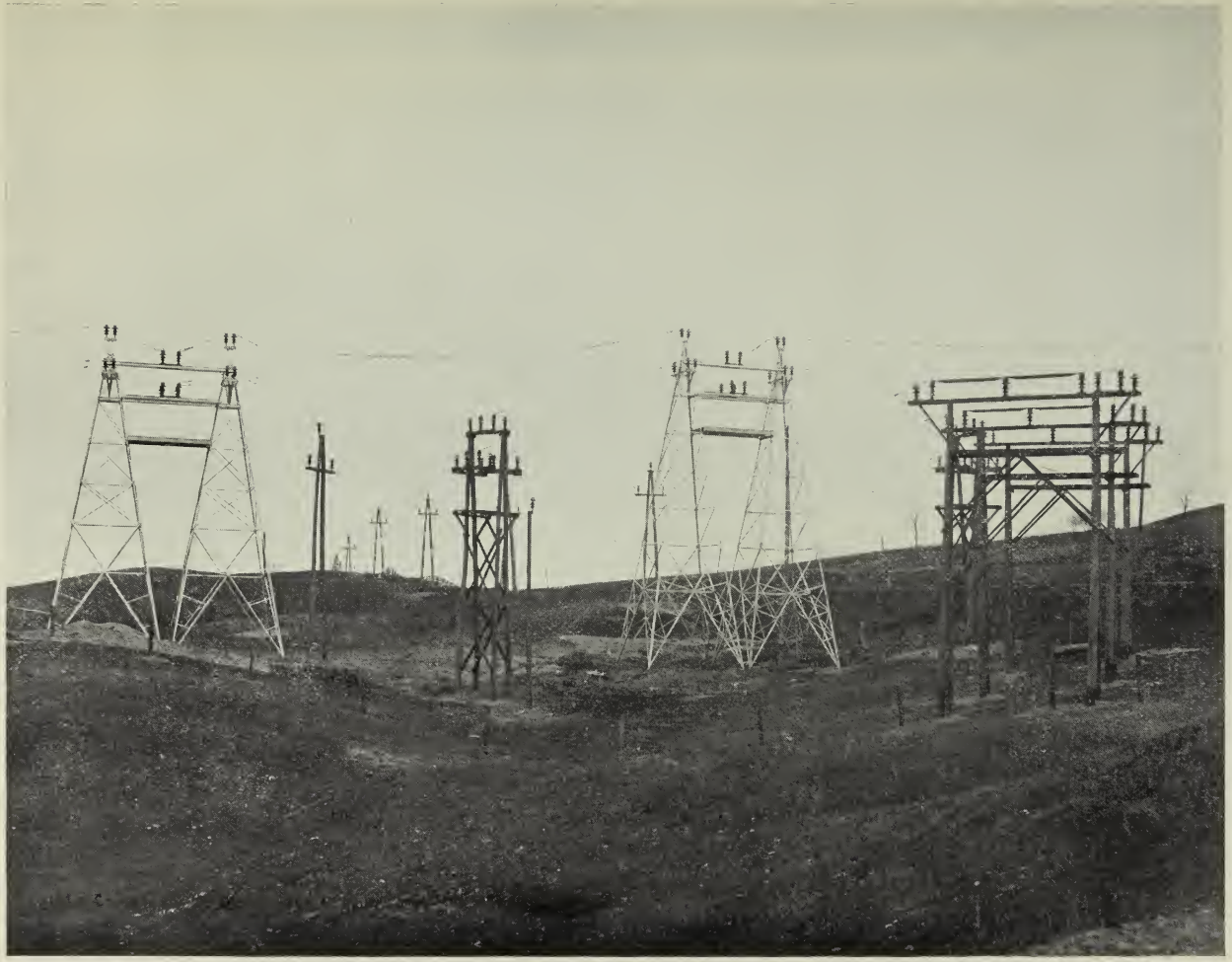
As previously stated, the power is brought across the Niagara River, by means of aerial cables spanning the river, and delivery of the power is taken by the transmission company at the international boundary line. The cables are brought across the river in three spans, one span from steel cantilevers at the top of the cliff on the Canadian side to steel towers at the water's edge on the Canadian side; another span from the water-edge towers on the Canadian side to the corresponding towers on the American side; and a third span from the steel water-edge towers on the American side to the steel cantilevers at the top of the cliff on the American side. The use of cantilevers is necessitated mainly by reason of the steep angle at which the cable descends from the top of the cliff. Their use also makes

1,253-FOOT SPAN OVER SWAMP

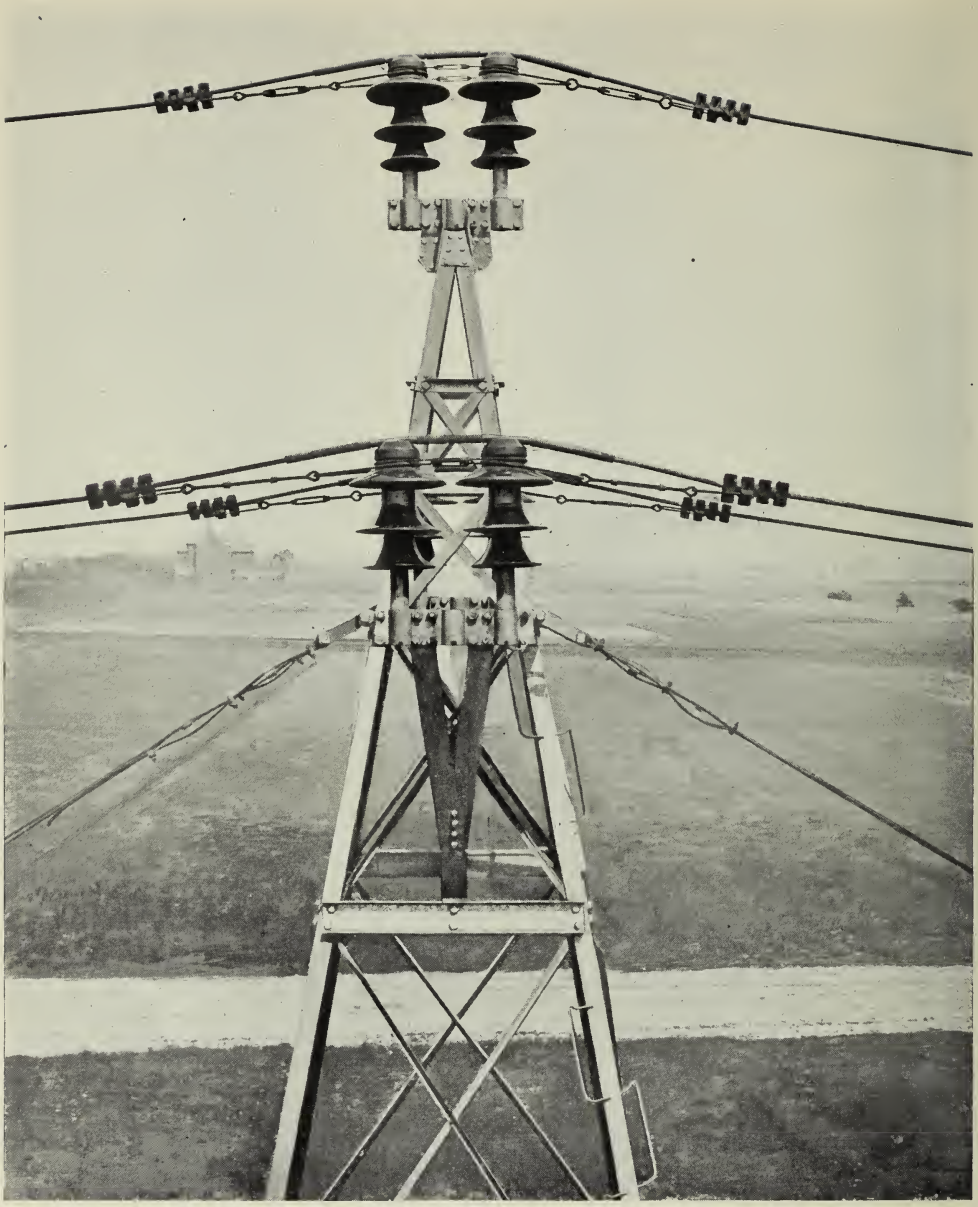
1,200-FOOT SPAN OVER OWASCO OUTLET

possible the required clearance between the cable and the slope of the gorge, a point of special importance on the American side in view of the fact that one of the branch lines of the New York Central Railroad is on the American slope of the gorge. The steep slope of the cable at the cantilevers would make it bear upon the upper petticoat of the insulator supporting it, if the cable were attached to the top of the insulator in the usual way. As will be seen by the photographs of the cantilevers, this difficulty is obviated by attaching the cable to a steel cross-bar supported at each end by an insulator.

The steel cantilevers and the river-edge towers are all designed to withstand the most extreme conditions of sleet and wind that will probably ever exist. The requisite mechanical strength of the insulation at the points where the cables are attached to the steel structures is obtained by using a sufficient number of line insulators, and the proper distribution amongst these insulators of the forces which will come upon them is effected by means of malleable cast-iron caps cemented to the tops of the insulators and to which the cables are fastened.



CROSS-CONNECTING AND DISCONNECTING SWITCHES AND OPEN AIR FUSES AT POINT OF JUNCTION OF AUBURN BRANCH LINE AND THE MAIN LINE



TOP OF DOUBLE-GUYED STEEL TOWER

It was originally intended, and provided for in the contract with the Ontario Power Company, that just after crossing the river, the 60,000-volt lines should be led into a switching station in which, by means of 60,000-volt electrically operated oil-switches, it would be possible to interchange the circuits coming into and going out of this station. The building itself for this switching station has been completed, but, before the equipment

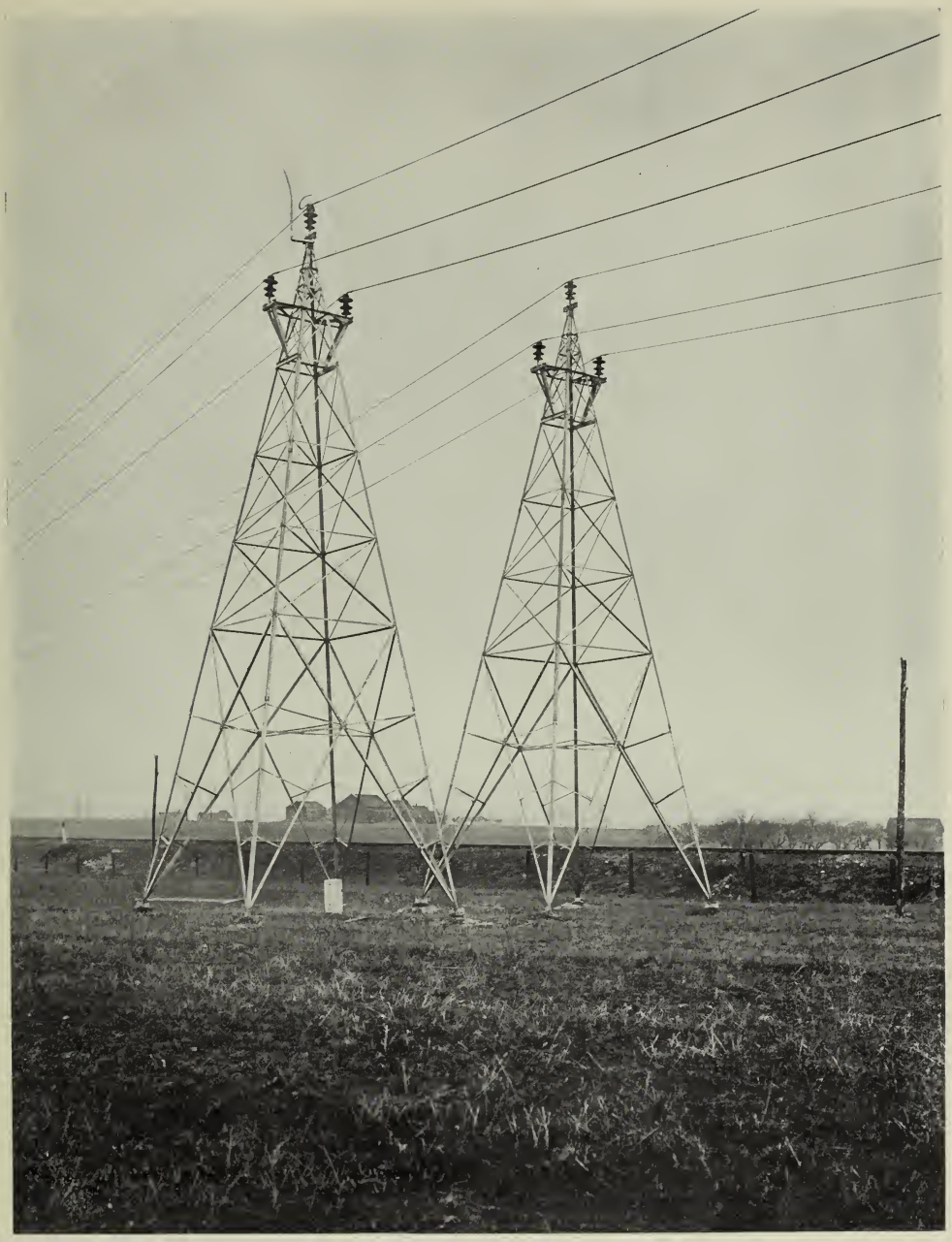
TOWER IN MONTEZUMA SWAMP

of the station had been installed, arrangements were made with the Ontario Power Company to defer the outlay for such equipment until the use of it should be more necessary than at the present time, when only two lines are in operation.

The main-line construction of the Niagara, Lockport and Ontario

Power Company is most substantial. With the exception of that portion of the main line on the West Shore between Churchville and Syracuse, the main-line structures are all steel towers, and the standard line-span is 550 feet. On some portions of the transmission line, however, much longer spans are used, the longest at present installed being 1,253 feet. In some cases, these long spans had to be provided with towers heavier than the standard, but in some cases it was possible to put them up with little, if any, modification of the standard tower construction. For a number of reasons, the principal one being lack of the requisite space, it was necessary to use on the West Shore right-of-way between Churchville and Syracuse wooden construction of special design which will be described later on, the standard span being 220 feet. In every case on the 60,000-volt lines, each line of towers or wooden structures carries only one three-phase circuit. The main line conductors installed so far are all of them of aluminum cable, except on a portion of the line between Mortimer and Syracuse where, because of the long spans employed, it is preferable to use copper.

The first of the steel towers installed were of the tripod type, made of lap-welded pipe; but the later towers, and those which in the near future will be installed, are of structural shapes and galvanized. The design of these two types of towers is shown in the accompanying illustrations. Two types of the structural tower are shown. The earlier ones were non-interchangeable; that is, the guyed towers differed in construction from the unguyed towers. The later towers are interchangeable; that is, the guyed and unguyed towers are exactly similar except for the guys and double insulators of the former. Contrary to the practice which has heretofore been followed in the matter of steel line towers, the towers of this transmission line are mounted on foundations of reinforced concrete. These foundations are designed to utilize the weight of the earth around them in resisting uplift. The towers and their foundations are capable of withstanding transverse forces which will be brought upon them when the line cables are covered with 0.5 in. of ice all around them and the wind blowing transverse to the line at a velocity of 75 miles an hour. The towers have the same strength in all directions; that is, they are capable of withstanding the same forces in the direction of the line that they are capable of withstanding transverse to the line; but to meet the contingency, not likely to occur, of all three cables breaking at once, in which case the full tension of all the cables might be brought upon the towers, there are at intervals along the line certain towers guyed both ways in the direction of the transmission line, and having double fixtures. The strength of these guyed towers is such as would enable them to withstand the forces which



LINE STRUCTURE LIGHTNING ARRESTER ON STEEL TOWER

would obtain under the extreme conditions outlined above, if all the line cables should break. The guyed towers will, therefore, terminate any progressive failure of the line which might, under extreme conditions, be instituted by breakage of the cables.

As stated above, on the West Shore right-of-way it was necessary to

STRINGING LINE CABLE

use wooden line structures. The type of construction employed is that which has been designated by the company as "A-frame construction." It is clearly shown in one of the accompanying cuts. By adopting this type of construction, in which each structure consists of two poles instead of one, it is possible to use twice the length of span that would be used in ordinary wooden pole construction, and employ, therefore, one-half the number of insulators. As stated above, the standard length of span of this type of construction is 220 feet. On some portions of the West Shore right-of-way it was necessary to use steel construction, and in such places there were installed galvanized lattice steel poles, such as are shown in one of the illustrations. The span on these poles is the same as that on the A-frame construction.

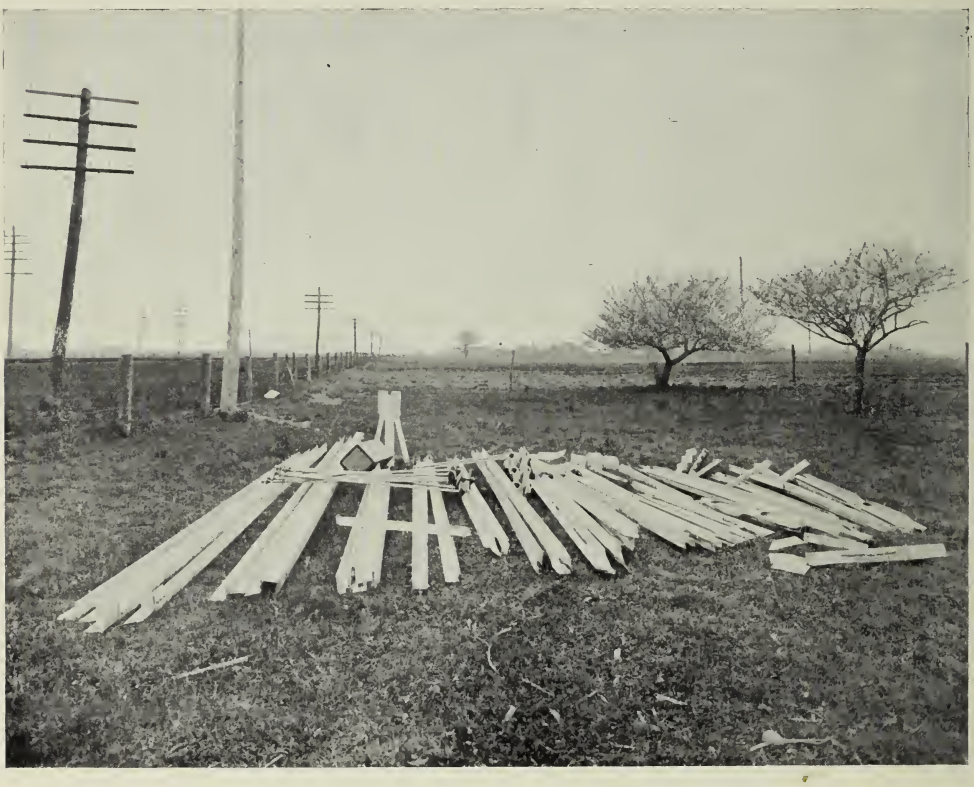
In a number of places on the main line, both on the West Shore and on the private right-of-way, it is necessary to cross the Montezuma Marsh. Where this marsh was crossed with steel tower construction, the concrete foundations for the steel towers were built by first excavating the swamp

through the soft mud until the soft marl, forming the sub-stratum of the swamp, was reached. On the marl was laid a platform of two layers of corduroy, and on this platform was built the concrete foundations, the weight of which was made sufficient to take care of any uplift which will come upon the towers. These foundations were installed, some of them, in cold weather and, so far, they have shown no settlement. Where this marsh was crossed with A-frame construction, it was found in places much too expensive to excavate for the proper foundation for the A frames. The A frames were, therefore, installed by laying on top of the ground, four line poles in two pairs; the poles of one pair being parallel to the line, and the poles of the other pair being at right angles to the line. These poles were spiked together at the point where they cross, and at the point of crossing the A frame spiked to them; the A frame being further secured to the poles by braces. On each end of each pair of poles was spiked a box, built up of planking and filled with stone, in order to give sufficient weight to take the uplift due to any pull at the top of the tower. This structure, while far from beautiful, has, so far, proved very satisfactory. The tower construction and the A-frame construction in swamps are shown in the illustrations.

It will be noted that, in some of the illustrations of the towers and A frames, there is shown a horn attached to a cap on the top of the insulator and another horn alongside of it fastened to the structure and extending some distance above the insulator. This comprises a combined line structure lightning-arrester, or spark-gap, and lightning-rod. It has been decided to make a careful trial of this method of protection of the line before resorting to a grounded cable; partly because of the great expense of the grounded cable, and partly because there is no reason to think, so far, that it will necessarily afford complete protection in every case. For the present, these line-structure lightning-arresters will be installed only on the top cable, in view of the fact that during the last lightning season, in the course of which a number of insulators were broken by lightning, more than three-fourths of the insulators so broken were top insulators.

The insulator used on all the main-line construction is one especially designed by the writer for this plant. It has probably the greatest factor of safety as regards flashing, etc., of any insulator in practical use to-day, and is considerably larger and heavier than any insulator of which corresponding use has heretofore been made. It consists of three shells nesting in each other and cemented together by means of neat Portland cement, the whole insulator being cemented in a similar manner to a steel pin before attachment to the tower. The insulator is clearly shown in one of the

illustrations. The total height of it from the edge of the lower petticoat to the top of the head is 19 inches. The diameter of the upper petticoat is 14.5 inches. The insulator used on some of the branch lines is smaller and less expensive than that for the main line, partly because the branch lines receive in general a somewhat lower voltage than the main line and partly because the lines, carrying the small amounts of power they do, are not considered to be entitled to the same insurance as the main line. Each branch line has in series with it, at the point where it is tapped off the main line, 60,000-volt outdoor fuses to cut out the line in case of trouble upon it.



TOWER DELIVERED READY FOR ASSEMBLING

The fuses consist of lengths of thin copper wire 16 feet long, run through an ordinary small rubber bathroom hose and laid in clips on top of a wooden bar, supported at each end and the center by line insulators mounted on poles. The fuses are parallel to each other, in the same horizontal plane, and the distance from center to center is about 25 feet. These fuses have so far proved very satisfactory, but will probably in time be replaced with fuses of the expulsion type. The outdoor 60,000-volt fuses are shown in one of the illustrations.

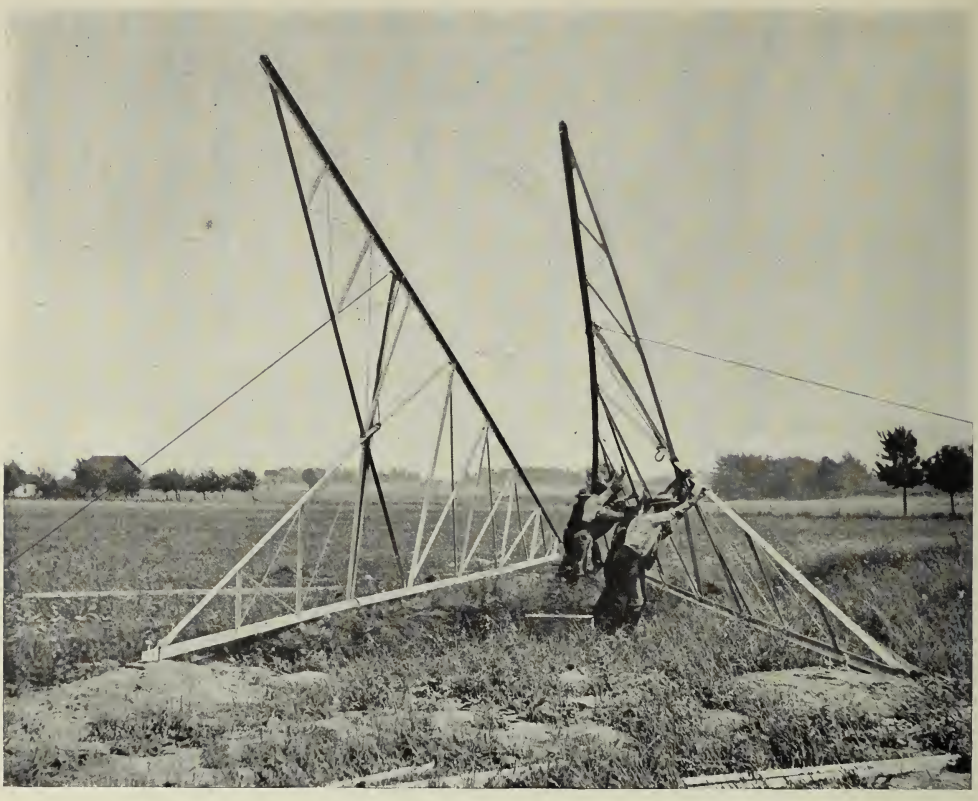
There are only three sizes of cables used on the main transmission line, designated by the company as ⅗, ⅖ and ⅕ respectively. The ⅗ cable is aluminum cable, consisting of 19 strands, and having a total area of 642,800 cir. mils, being equivalent to 400,000 cir. mils copper. The areas of cross-section of the other cables are respectively ⅔ and ⅓ that of the large one.

In ordinary straight-away work, the cables lie in the top groove of the insulator, and the pull of the cable is taken care of by means of two aluminum wire ties around the neck of the insulator. One of these ties extends each way along the cable. The tie itself consists of a single loop around the neck of the insulator, the two ends of the loop being twisted around the line cable. The result is that the cable is not really fastened to the insulator

ASSEMBLING TOWER (1)

at all, but simply lies in the top groove. The ties do not, therefore, perform any function, except when there is a pull on the cable tending to slide it in the direction of its length. The advantage of such a tie is twofold. First: the full strength of the tie wire is developed, which is not the case if a tie is twisted of "pig-tailed," since, in such case, the tendency is for the tie to cut itself in two at the twist; secondly, the tie does not damage the soft aluminum cable, as would be the case with most of the other ties usually employed.

In other than straight-away work, and where it is desirable that the method of fastening to the insulator shall be such as will withstand a pull equal to the full strength of the cable, in case the cable should break,



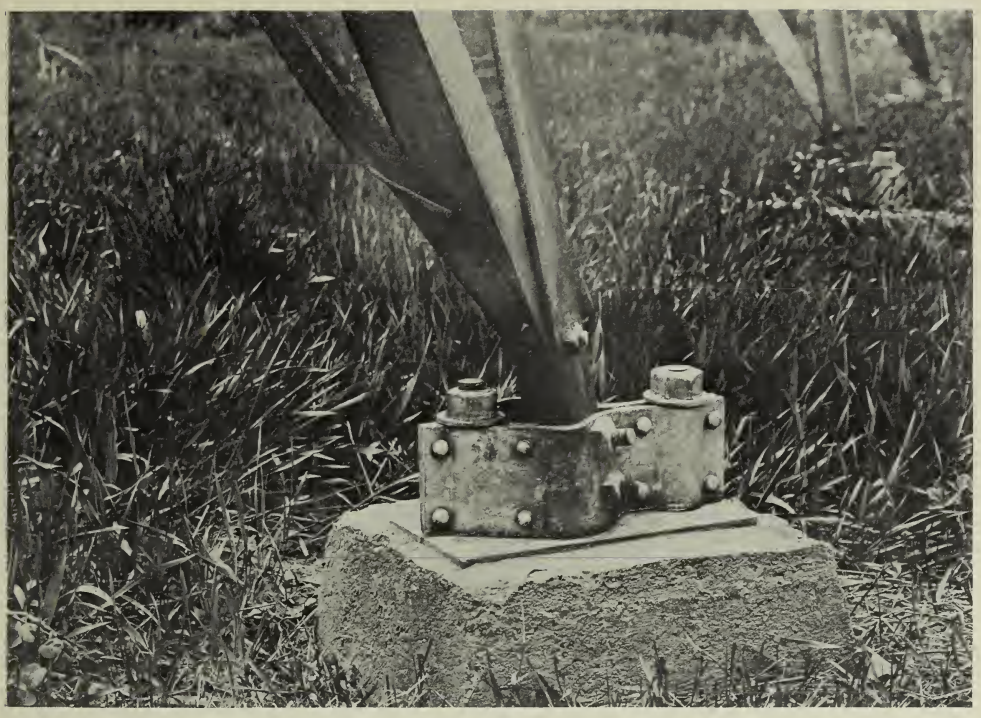
ASSEMBLING TOWER (2)

the tie mentioned above is not used, but instead there is employed a cable-clamp and a yoke extending each way on the cable.

In every case, the cable near the insulator is protected from possible arcs, so that in the event of an arc there will be a chance for the circuit-breaker at the generating station to open before the cable shall have been burned off. This protection is accomplished in the top groove of the insulator by means of sheet aluminum wrapped around the cable at this point to a thickness of $\frac{1}{8}$-inch, and is accomplished on each side of the head of the insulator to a distance of 12 inches from the head partly by the turns of the tie-wire mentioned above, and partly by an additional serving of tie-wire. Where, in the case of the use of cable clamps, no tie-wire is used, its absence is made up for by additional serving. The photographs show very clearly the methods of attachment of the cables to the insulators and the methods of protecting the cables from arcs.

The ends of the line cables are connected by means of twisted sleeve joints. The method of making these joints is shown in the illustrations.

At intervals along the line, there are provided disconnecting switches for

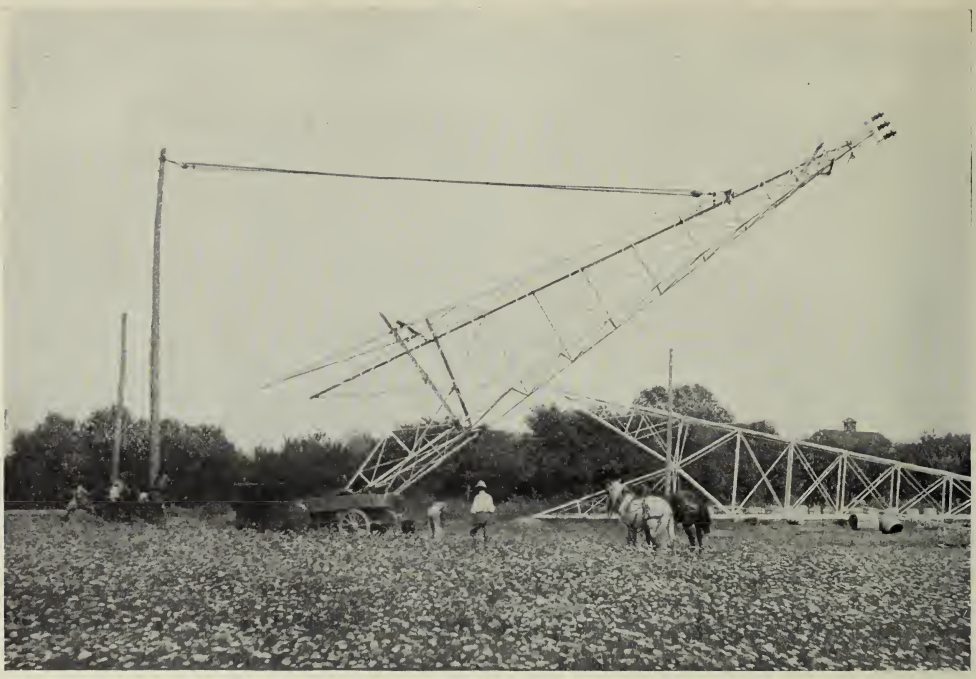


FOOT OF TOWER, SHOWING METHOD OF FASTENING TOWER TO FOUNDATION

TOWER FOUNDATION DUG UP FOR PURPOSE OF RELOCATION

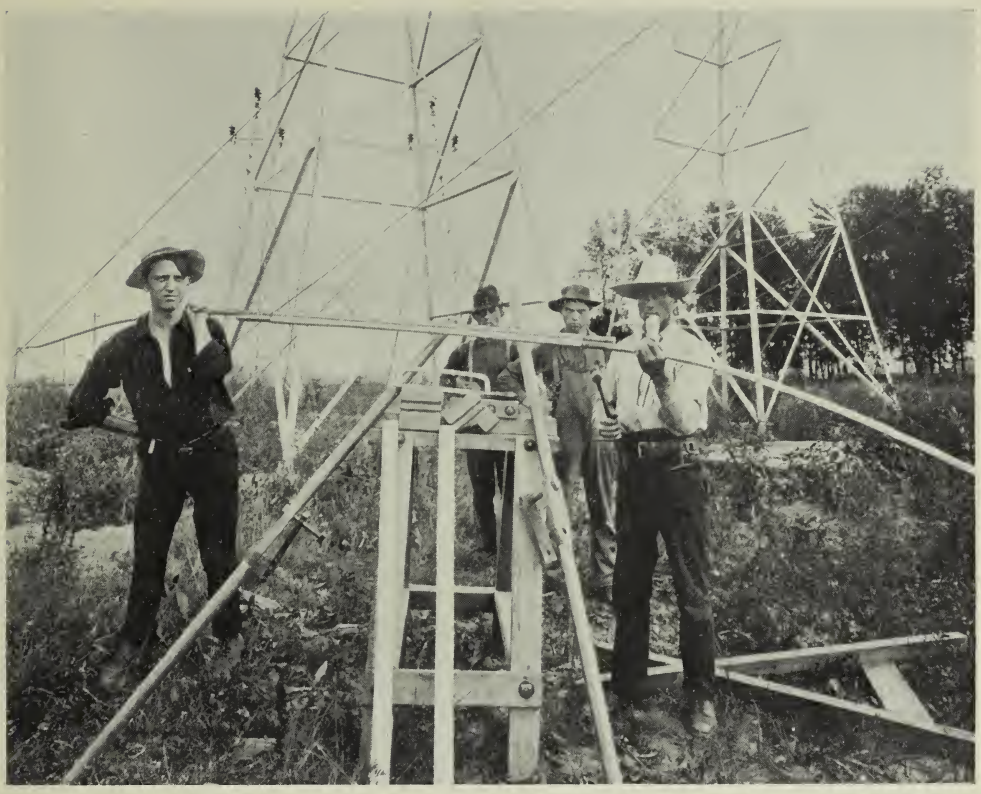
sectioning the line to facilitate testing out in case of trouble, or cutting out any portion of the line which is damaged. There are also provided at certain points in connection with these disconnecting-switches, cross-connecting switches, enabling the interconnection of different portions of the two lines.

On a considerable portion of the company's right-of-way is a wagon road, for use in patrolling the line and delivering materials for construction or repair. At certain points along the line there are patrol houses for the storage of material, for taking care of teams and for the comfortable housing of the patrolmen. Each house has in it sleeping room, kitchen, and



ERECTING 75-FOOT TOWER (1)

ERECTING 75-FOOT TOWER (2)



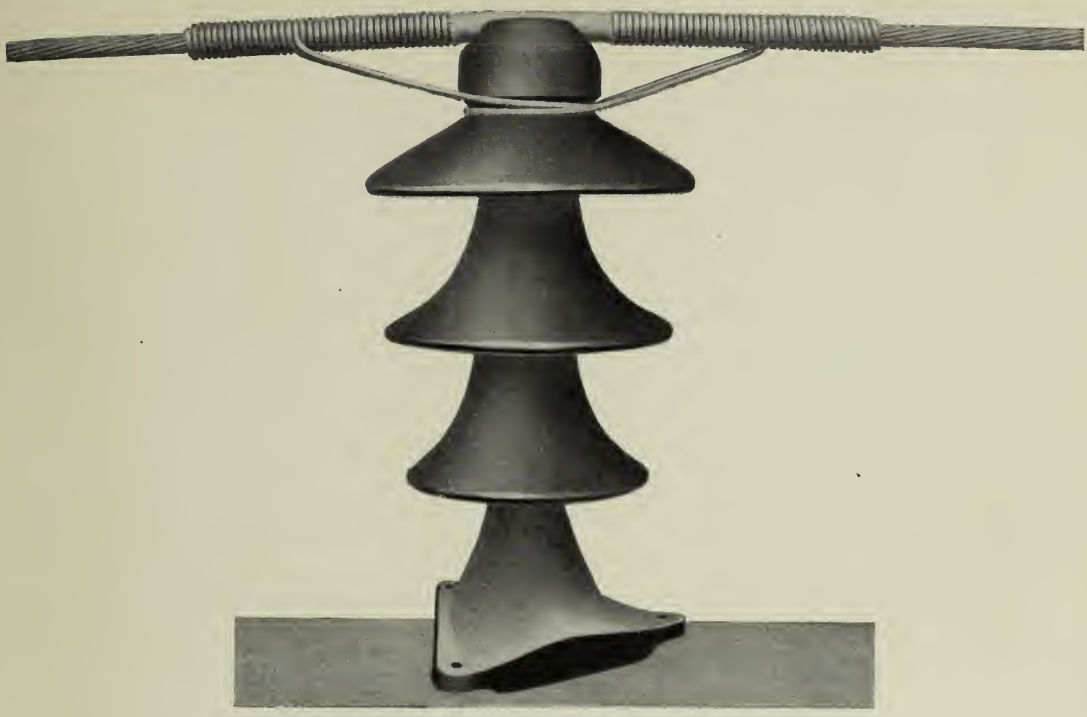
THE MAKING OF A JOINT (1)

sitting room. On all of the transmission lines, also, the company has a private telephone line on a separate set of wooden poles. Taps from this line are brought into each of the transmission houses, and in addition to this, the line patrolmen have portable telephones which can be connected to the telephone line at any point.

Most of the contracts which the company has for the supply of power cover the delivery of the same at the main-line voltage, so that, so far, the company has installed only three sub-stations, two of them of considerable size at Lockport and Gardenville respectively and one at Baldwinsville, a very small and comparatively inexpensive one. The stations at Lockport and Gardenville have, each, a normal capacity of 3,000 K.W. not including the spare apparatus. They are so designed that their capacity can be indefinitely increased. The Baldwinsville station has a capacity of 750 K. W. The station at Lockport has been installed and in operation for sometime. That at Gardenville is about complete, but not yet in operation. The accompanying illustrations will, in a general way, make clear the type of construction employed in the Lockport and Gardenville sub-

THE MAKING OF A JOINT (2)

THE MAKING OF A JOINT (3) JOINT COMPLETE



60,000 VOLT MAIN LINE INSULATOR WITH TIE AND CABLE PROTECTION

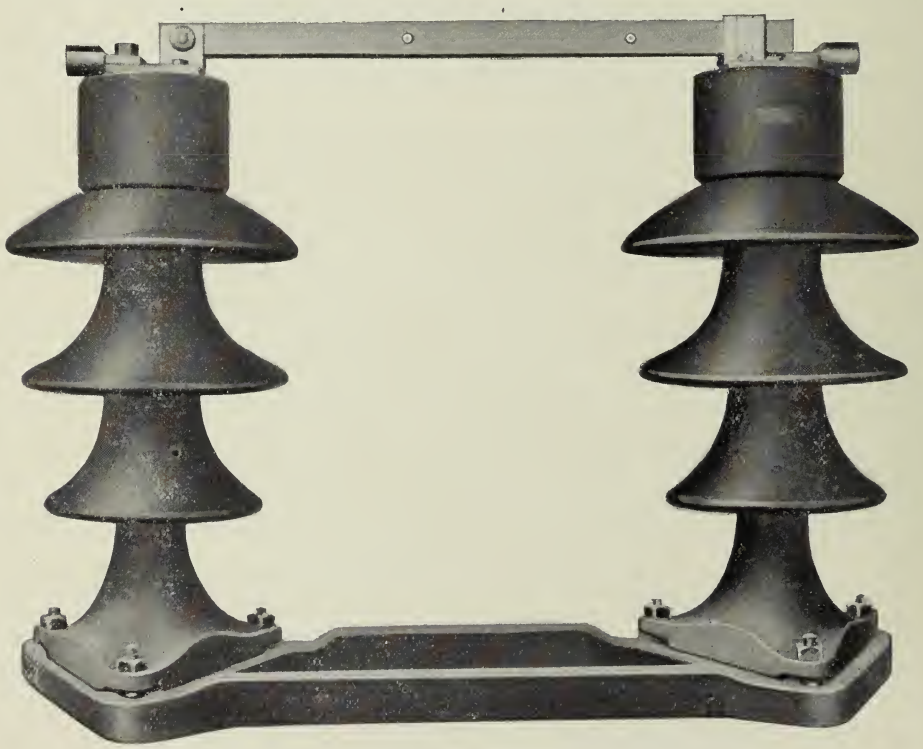
stations; but as there are a number of features in connection with these sub-stations which are quite different from ordinary practice in these matters, a brief description of them will be in order.

The 60,000-volt bus-bars at these sub-stations are outdoors; in other words, these bus-bars have been treated exactly as if they were part of the transmission line and located out of doors in a manner, so far as insulation is concerned, similar to the transmission-line cables. In connection with them are disconnecting-switches as shown in the accompanying cut for making various combinations of the apparatus connected to them. Of course, the disconnecting-switches are not intended to break the working current. When it is necessary to break the circuit under load, it will be accomplished by means of the 60,000-volt electrically operated oil-switches installed in the station which, in the case of the Lockport sub-station, serve also for the control of the two lines to the Buffalo district.

Another feature out of the ordinary in connection with this station is the lightning-arrester equipment. This equipment is also out of doors, and consists of a number of horn-type lightning-arresters mounted on wooden poles in much the same manner as such arresters are ordinarily mounted. The installation differs, however, from the ordinary lightning-arrester instal-

lation of this kind in that, instead of there being only one pair of horns for each line conductor, there are three such pairs. One pair is set for a comparatively low striking electromotive force and has in series with it a high resistance; the next pair is set for a higher striking electromotive force, and has in series with it a lower resistance; a third pair is set for very high striking electromotive force and has in series with it a fuse.

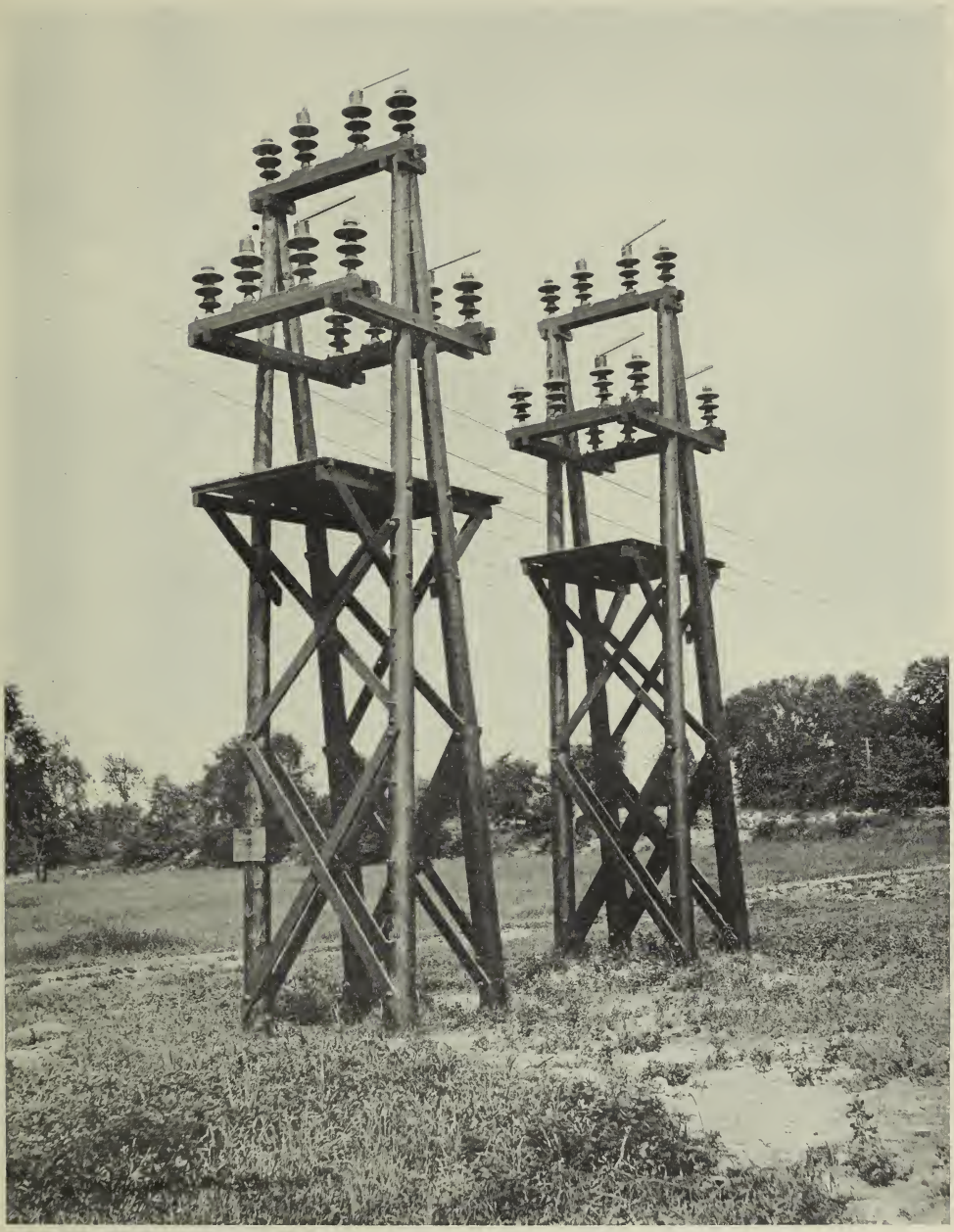
The theory on which these arresters are installed, is that for ordinary slight static disturbances in the line the arrester having the lower striking electromotive force will discharge, and since it has in series with it a comparatively high resistance the resultant disturbance to the system due to the generated current which follows the discharge will be comparatively slight. A more severe static disturbance (whether due to lightning or to any other source), will cause both the arrester having the lowest gap and the arrester having the next higher gap to discharge simultaneously, thus affording two discharge paths to earth, the combined resistance and inductance of which is considerably lower than that of the first path. This will mean a somewhat more severe disturbing effect on the system due to the generated current which follows. In the case of a very extreme condition, for instance, a direct lightning stroke on the line, the three arresters would



60,000 VOLT OUTDOOR LINE DISCONNECTING SWITCH

STANDARD A-FRAME CONSTRUCTION SHOWING LINE STRUCTURE LIGHTNING ARRESTER

A-FRAME CONSTRUCTION MONTEZUMA SWAMP



A-FRAME DISCONNECTING SWITCHES

A-FRAME TRANSPOSITION

GALVANIZED STEEL POLES ON RAILWAY

LOCKPORT SUB-STATION SHOWING 11,000 VOLT OUTDOOR LIGHTNING ARRESTERS

discharge simultaneously, the fuse, in the case of the arrester with the highest air-gap, blowing and interrupting the arc upon it, the disturbance of the circuit finally ending upon the other two arresters. Judging from experience in the case of other plants with a much less elaborate arrangement than that outlined, and the experience during the last lightning season with the protection afforded at the Lockport station, the writer believes this method of protection to be entirely effective in the matter of preventing damage to apparatus in the sub-station. Such an installation may, in the case of a very severe discharge, such as that due to a direct stroke of lightning, mean a temporary shutdown of the system, or at any rate of the synchronous apparatus operating upon it; but it does not necessarily follow that this will be the case if expulsion fuses be used on the highest gap arrester. Such fuses as have been experimented with in connection with this work operated very satisfactorily. It may be noted in passing that a lightning-arrester equipment similar to that just described for sub-stations is installed also at each point where a branch line is taken off of the main line.

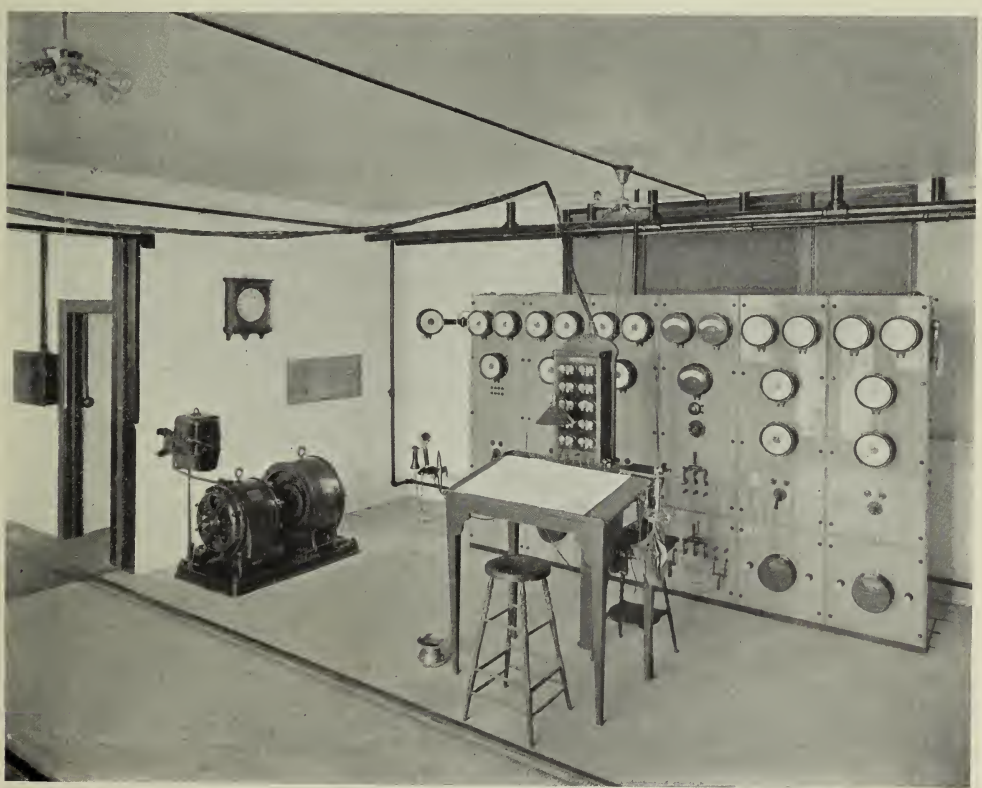
The other features of this station are very similar to those usually found

LOCKPORT SUB-STATION SHOWING OUTDOOR 60,000 VOLT BUS-BARS

TRANSFORMER ROOM, LOCKPORT SUB-STATION

in such an installation. There is a complete system of oil piping for putting oil into or removing it from the transformers and oil-switches, and also for storing oil, to replace that in the transformers and switches when it may become necessary. There is also provided, outside of the building, an oil-storage tank for storing oil that has been damaged, until such time as it is convenient to put it through the oil-cleaning apparatus. In view of the fact that there is no other continuous water supply available at this sub-station, it has been necessary to drill wells for the supply of water for cooling the transformers. In connection with these wells there has been installed a pumping plant, a water tower and a cooling pond, the latter for use in case the wells should not be able continuously to supply all the water required.

There will be installed shortly on the company's system two switching stations, one at Mortimer and one at Syracuse. The one at Syracuse will be for taking care of the two incoming 10,000 horse power lines and the outgoing lines to the consumers in Syracuse. The one at Mortimer will be for taking care of the two incoming 20,000 horse power lines and five

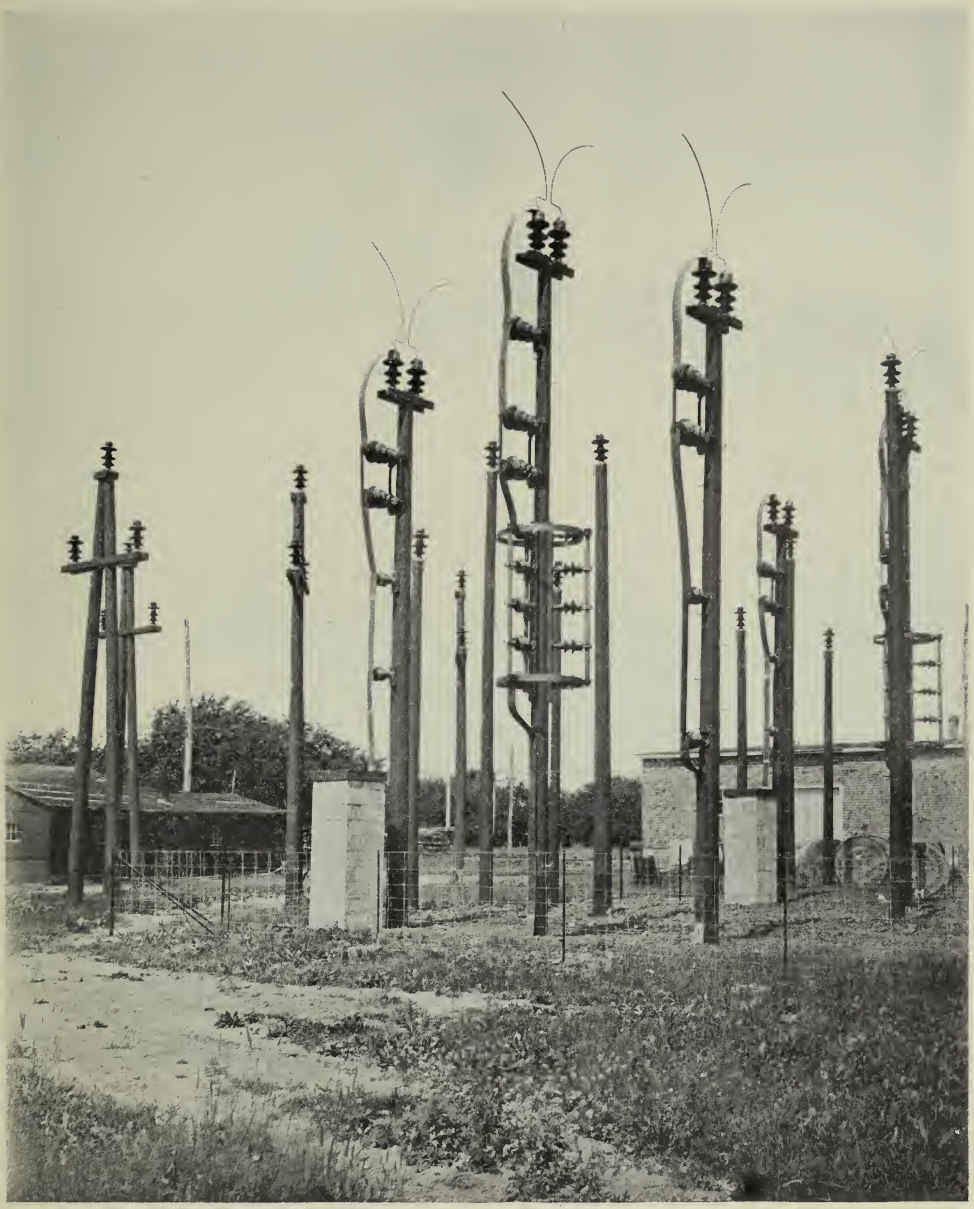


SWITCHBOARD ROOM, LOCKPORT SUB-STATION

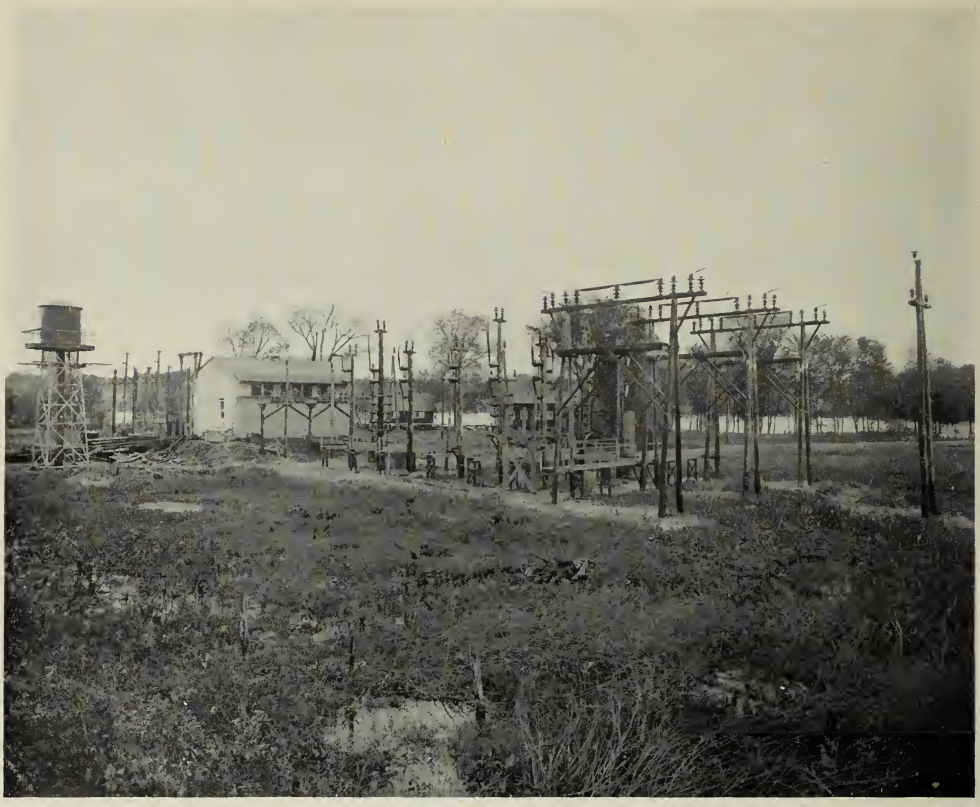
60,000 VOLT OIL SWITCH AND CIRCUIT BREAKER; ELECTRICALLY OPERATED

outgoing lines, two of them being a line in duplicate to Rochester; two of them the line in duplicate to Syracuse, and one the Avon Branch line, supplying several installations, amongst them the station of the Erie Railroad Company, operating their trolley line between Rochester and Avon. Both these switching stations will be equipped with the 60,000-volt electrically operated oil-switches, reverse relays and other apparatus necessary for properly manipulating the circuits which they control.

The transmission lines of this company cross the rights-of-way of a number of railway companies, and some difficulty has been had in arriving at a satisfactory arrangement with the railways in regard to these crossings. In general, the attitude of the railways is that of being unduly fearful of the transmission lines, and requiring protective precautions of one kind or another. It is, however, gratifying to note that in every case the railway companies have, on investigation, been so well satisfied with the reliability of the transmission company's type of line construction as to waive the elaborate steel protective bridges which have been insisted upon at times in the past, and in most cases little or no extra precautions have been required.



60,000 VOLT LIGHTNING ARRESTER EQUIPMENT; TWO 3-PHASE CIRCUITS



BALDWINSVILLE SUB-STATION, SHOWING LIGHTNING ARRESTERS

The transmission plant has been built in accordance with the designs of the writer, acting as chief engineer of the Niagara, Lockport and Ontario Power Company, and has been constructed under his supervision and that of his assistant in the work, Mr. H. L. St. George. The construction work has been done by the Iroquois Construction Company, of Buffalo, headed by General Francis V. Greene, President; the construction work itself being directed by Mr. F. B. H. Paine, Vice-President and Chief Engineer of the Construction Company, assisted by Mr. Walter S. Skinner and Mr. S. Piek.

TYPICAL PATROL HOUSE

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